

# Perchloroethylene-Contaminated Drinking Water and the Risk of Breast Cancer: Additional Results from Cape Cod, Massachusetts, USA

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In 1998 we published the results of a study suggesting an association between breast cancer and perchloroethylene (PCE; also called tetrachloroethylene) exposure from public drinking water. The present case-control study was undertaken to evaluate this association further. The cases were composed of female residents of eight towns in the Cape Cod region of Massachusetts who had been diagnosed with breast cancer from 1987 through 1993 ( $n = 672$ ). Controls were composed of demographically similar women from the same towns ( $n = 616$ ). Women were exposed to PCE when it leached from the vinyl lining of water distribution pipes from the late 1960s through the early 1980s. A relative delivered dose of PCE that entered a home was estimated using an algorithm that took into account residential history, water flow, and pipe characteristics. Small to moderate elevations in risk were seen among women whose exposure levels were above the 75th and 90th percentiles when 0–15 years of latency were considered (adjusted odds ratios, 1.5–1.9 for > 75th percentile, 1.3–2.8 for > 90th percentile). When data from the present and prior studies were combined, small to moderate increases in risk were also seen among women whose exposure levels were above the 75th and 90th percentiles when 0–15 years of latency were considered (adjusted odds ratios, 1.6–1.9 for > 75th percentile, 1.3–1.9 for > 90th percentile). The results of the present study confirm those of the previous one and suggest that women with the highest PCE exposure levels have a small to moderate increased risk of breast cancer. **Key words:** breast cancer, drinking water, perchloroethylene, pollution, tetrachloroethylene. *Environ Health Perspect* 111:167–173 (2003). [Online 25 October 2002] doi:10.1289/ehp.4980 available via <http://dx.doi.org/>

Perchloroethylene (PCE; also called tetrachloroethylene) is a chlorinated solvent commonly used in industrial operations such as dry cleaning, textile processing, and metal degreasing [Agency for Toxic and Substances and Disease Registry (ATSDR) 1995]. Because PCE is mainly used in small, geographically scattered, and poorly controlled workplace settings, it has become a common contaminant of drinking water and Superfund sites.

Although industrial disposal is the typical source of drinking water contamination, PCE leached into the drinking water supplies of Cape Cod, Massachusetts, from an inner vinyl liner that was present in certain asbestos cement pipes (Larsen et al. 1983). The vinyl liner was introduced in the late 1960s in response to taste and odor complaints. A slurry of a vinyl plastic and PCE was used to coat the inside of the pipes just before shipping. The manufacturers assumed that the volatile PCE would disappear during the drying process; however, substantial quantities remained and slowly leached into the drinking water supplies.

More than a decade lapsed before the Massachusetts Department of Environmental Protection (DEP) learned that the vinyl liner was a source of PCE contamination. A survey in 1979 revealed that 660 miles of the vinyl-lined asbestos cement (VL/AC) pipe had been installed in Massachusetts, predominantly in the Cape Cod region (Massachusetts

Department of Environmental Quality Engineering 1982). Typical levels in affected towns ranged from 1,600 to 7,750  $\mu\text{g/L}$  in low-flow locations, and from 1.5 to 80  $\mu\text{g/L}$  in medium- and high-flow locations (Demond 1982). DEP began a regular program of flushing and bleeding to correct the problem in 1980.

In response to public concern about elevated cancer rates and environmental pollution in the Cape Cod area, we conducted a population-based case-control study to evaluate the relationship between nine types of cancer and air and water pollution, including PCE-contaminated drinking water (Aschengrau et al. 1998; Paulu et al. 1999). Although our study suggested that women with high relative delivered doses (RDDs) of PCE-contaminated drinking water have an increased risk of breast cancer, firm conclusions were limited by the small proportion of exposed subjects, particularly when long latent periods were considered. We undertook the present study with a larger number of more recently diagnosed cases in order to evaluate further the hypothesis that PCE exposure increases the risk of breast cancer. The biologic rationale for our study stems from a hypothesis recently described by Labreche and Goldberg (1997) that organic solvents such as PCE may act either directly as genotoxic agents or indirectly through their metabolites to increase the risk of breast cancer.

## Materials and Methods

### *Selection and enrollment of study population.*

The case group was composed of women diagnosed with breast cancer from 1987 through 1993 who were permanent residents of eight Cape Cod towns (Barnstable, Bourne, Brewster, Chatham, Falmouth, Mashpee, Provincetown, and Sandwich) and whose diagnosis was reported to the Massachusetts Cancer Registry. Comparison of the Massachusetts Cancer Registry with other state cancer registries indicates nearly complete ascertainment for breast cancer (Massachusetts Department of Public Health 1995). For the vast majority of cases (94.6%) this was the first occurrence of breast cancer, but for a small percentage (5.4%) this was the second occurrence of a primary tumor.

The control group was composed of similarly aged women who were also permanent residents of the eight Cape Cod towns during 1987 through 1993. Because most cases were elderly and many were deceased at the start of data collection, three sources were used to identify controls in an efficient manner: *a*) living controls  $\leq 64$  years of age were selected by random-digit dialing; *b*) living controls  $\geq 65$  years of age were randomly selected from a roster of Medicare beneficiaries provided by the Health Care Financing Administration (HCFA); and *c*) deceased controls were randomly selected from a roster of deceased residents of the eight Cape Cod towns provided by the Massachusetts Bureau of Health Statistics, Research, and Evaluation. The number of controls selected from each source was weighted to reflect the age and vital status distribution among cases.

Random-digit dialing identified a random sample of female telephone subscribers  $\leq 64$  years of age who lived in the study

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